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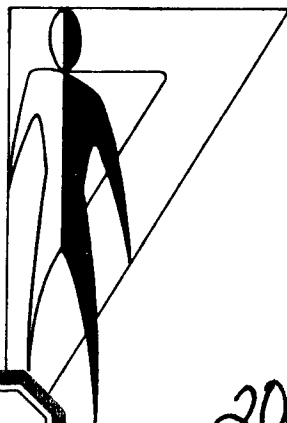
A PARTIAL REVIEW OF THE LITERATURE ON  
PHYSIOLOGICAL DISORDERS RESULTING FROM THE  
OPERATION OF MOTOR VEHICLES

John W. Lewis

August 1962

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HUMAN ENGINEERING LABORATORIES



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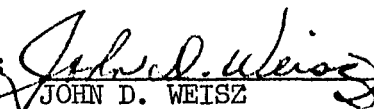
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## **Abstract**

A review of available literature on physiological difficulties arising from riding and driving automotive vehicles is presented. Findings indicate that a number of physical complaints show causes arising from the shocks and vibrations transmitted to the operator as a result of inadequate consideration of seating and suspension.

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## Introduction

This literature review is one of the first steps taken by the Human Engineering Laboratories in the development of a seat design for military vehicle drivers.\*

There have been and are innumerable seat designs. The only justification for another one is evidence of physiological injury or of degradation in performance resulting from the use of available seats. For our purposes, this paper will be limited to an inquiry of the physiological rather than the psychological effects of seating. The reason for this limitation is simple. Psychological deterioration from driving and riding is more difficult to measure, and the results are more difficult to interpret than the physiological. This does not mean that the latter is simple of ascertainment. The former, however, is deeply involved in relative intangibles such as fatigue, motivation, interest, stress, comfort, et al.

To choose only one of these, much has been said in the literature about comfort. Comfort is an ill-defined term, not at the moment accessible to operational definition, and may indeed always remain purely subjective. It depends on motivation, interest, habituation, etc. When the time comes that such intangibles can be objectively measured and the effect of subjective discomfort can be made obvious, then comfort can be considered as a measurable design factor. At present, however, this is not true. Therefore, we are considering here only the physiological effects that sitting in a moving vehicle has on an individual. While of extreme interest to the total efficiency of a vehicle driver, the areas of vision, hearing, toxicity, etc., are not included. We will concern ourselves solely with the effects that a seat and the vibration accompanying the operation of automotive equipment have on the spine, pelvic areas, intestines, etc., of an individual in the vehicle.

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\* This seat design incorporates four steps:

1. The present report.
2. An historical review of tank drivers' seats.
3. An instrumentation package for driver and seat.
4. A seat designed in accordance with physiological requirements of personnel in the vehicle environment.

## Procedure

A survey of available medical literature has been attempted to obtain information on the physiological effects of riding in a vehicle.

An examination of the card indexes of the Library of Congress and the National Library of Medicine, of the monthly listings of the Index Medicus for the past 25 years for as many pertinent and related items as could be determined, and a review of the literature by ASTIA, bring only a few articles to light devoted to this subject (see Bibliography). Perhaps much more information is available under specific subject matter headings on specific diseases of the spine, perineal areas, et al., but such a review of related literature would be extremely time-consuming and would not be feasible without the services of medical research specialists.

## Discussion

At the beginning of this review, a cursory appraisal had led to the belief that a good deal of clinical literature was available on this subject. Detailed investigation has, however, indicated that such is not the case. The few articles available in English specific to this subject (Clayberg, 5; Fishbein, 7; Paulson, 16) have been referred to again and again. Information in untranslated literature from foreign medical sources, especially that published in the Slavic languages, is relatively unavailable to the English-speaking audience.

In actuality, little study has been given to and almost no emphasis has been placed on this subject anywhere. Sternick et al (17) include a number of pages on ride comfort but only two short paragraphs on "Effect of Ride on Health", stating that it is a problem that should be looked into but that is beyond the scope of their study.

The type of information we are interested in is largely in the realm of pathology, which poses one of the major difficulties. The medical literature tends to report selected cases which illustrate a type of pathology of especial interest to the doctor writing the article. Much information in all probability lies buried in medical literature, and can only be exhumed by monumental effort.

A lack of interest in the relations between ailments and driving apparently exists. Studies on vibration have been largely concerned with psychophysical measurements on performance and on comfort and, admittedly, under laboratory test conditions no one can attempt seriously to reproduce situations which would cause lasting injury to the experimental subjects.

Another reason that few or no statistics are available in the areas with which we are concerned is that in most cases the effects are more likely to result in lowered efficiency by reason of almost subclinical symptoms than by dramatic incidence of trauma (Busch, 4: "...of course (these injuries) are not found equally in every individual"). The lack of information on the relation between driving and any type of pathology seems an obvious oversight in a country where so few walk and so many work at jobs in which riding or driving consumes a large portion of the daily effort. The literature that does exist indicates an awareness of these problems, but does not give adequate methods of attacking them.

The difficulties inherent in defining physiological correlates of driving and riding partake of the same problems of multiple causation with which the biological and social sciences have been plagued since their inception.

For instance, some of the variables are the range of seat designs, vehicle suspension, vehicle use, length of operation, and human physiological conformations and tolerances. These multiply into an enormous number of conditions, all of which may have an effect on the final results.

People have been concerned over the problems arising from inadequate seating in furniture - for instance, Travell (19).

Keegan (11), in one of the more thorough studies that have been made on seating and on chairs in general, has this to say:

"...only young persons with elastic ligaments and no back pain can tolerate sitting for long in the type of seats commonly designed.

"...It now is recognized that the site of most back symptoms arising from postural factors is in the lower lumbar spine, particularly in the fourth and fifth lumbar intervertebral discs, which commonly degenerate with age under normal weight-bearing, sitting, and stooping strain."

He feels that "While persons with normally elastic intervertebral discs and ligaments can subject their lumbar spines to considerable stress and strain without discomfort or disability, there is an increasing tendency in those over 30 years of age to experience lower lumbar pain associated with postural strain, and few individuals pass 40 years of age without feeling at times some lower lumbar soreness or pain ... Thus it is seen that, during sitting, support of the lower lumbar spine over the fourth and fifth lumbar discs is very important for persons with any degeneration or tendency to posterior protrusion of these intervertebral discs."

The above articles indicate awareness by medical personnel that physiological problems exist arising from or caused by the form and structure of the device used for seating. The concern of Keegan and Travell is limited to the static situations of home, office, and public exhibition or conference halls. It may reasonably be assumed that the dynamic seating situation found in many vehicles can be the cause of even more kinds and degrees of physical difficulty than they have noted.

Basically, our concern is limited to military vehicles - wheeled and tracked. Little information specific to this area was found, so use has been made of whatever information was available on civilian vehicles and tractor operations. Only one article, Clayberg (5), was directed to the military situation.

At first glance, Clayberg's article seems, from its title and coverage, to explicitly define and solve our problems. He indicates experience both in the military and in the pre-World War II CCC's. The report is, however, disappointing. It seems largely a compilation of hearsay evidence and somewhat specious assumption, although in some instances the author reports the results of examinations which he personally conducted.

The following extensive quotations from Clayberg indicate the tenor of his article and include what appears to be the most significant part of what he says:

"Renal irritation is the first and most constant complaint of drivers, but it is more particularly noted on rough terrain or bad roads. Some drivers are more sensitive than others to this mechanical type of renal stimulant. The initial effect is diuretic in type, with a secondary accompanying thirst. This interrupts the continuity of travel, and delays arrival at destination, or contributes to discomfort of driver, depending on the military necessities and dangers of the driving period.

"Secondary effects, especially if renal fascia be not strong and perirenal fat pad not well developed, is (sic) production of nephropsis, unilateral or bilateral, in time incapacitating the driver, even for light duties in other fields, and rendering him an ineffective. Later he may develop, as a result of such malpositions, ureteral displacement or torsion, with intermittent block of one or both ureters, and unilateral or bilateral hydronephrosis. Or this block may produce uraemia chronica, at first mild in grade, but sufficient in time to turn an active healthy man into a chronic invalid, and render him a military ineffective.

"The driver will complain of the constant jarring, even if none of the other above described effects are produced. It may sour his temper and embitter his relations with associates and superiors, producing an irritable quarrelsome disposition, and so impairing his adjustment to the unit to which he is assigned that transfer to other activities or branch of service, or discharge becomes necessary. However, as a general rule, the effects in this category do not pass beyond the nagging pain or discomfort in the dorsolumbar area, which is lost when the vehicle stops and he walks about, leaving only modicum of querulous complaint from him."

Much of what Clayberg says in the last paragraph can be taken with a grain of salt. It would be difficult, if not impossible, to correlate the psychological symptoms he lists with the jarring of a motor vehicle, although the writer has heard many verbal, non-verified reports that a jarring vehicle causes increased diuresis.

The difficulties mentioned before regarding multiple causation apply here, even though clinical observation may find Clayberg's assumptions valid. The following paragraphs from Clayberg would be even more difficult to verify. The comment on breaking the retinal synapses seems extremely unlikely of experimental verification.

"Brain irritation may also result from constant jarring, impairing ability of driver to think rapidly and clearly in emergencies, and lowering his mental and adaptive capacity and level, probably by frequent interruption of essential synapses in necessary sensory and motor paths. This, again, is subject to individual variation, and sensitive cases are not numerous. The same impairment in consciousness is noted by the blurring of its (sic) experienced by a runner, the jarring being furnished by serial impact of feet on the ground.

"Ocular irritation may result from constant jarring, with the same results as above. Breaking of retinal synapses may interfere with prompt visual recognition of location at crossroads, reading of signs, or grasp of dangerous situations liable to eventuate in accidents. All are exaggerated by refractive errors if uncorrected."

In his remarks on gastric upsets Clayberg may be on firmer ground:

"Gastric upsets. These may result from jarring. A sense of weight in the epigastrium or of nausea is present."

Other clinical literature supports the statement that gastric upsets may result from the jarring to be found in vehicle operation (Paulson, 16; Desse, 6). The following table from Paulson show some of the symptoms he found which he related to tractor driving:

TABLE 1

Complaints in 23 Patients - Paulson ,

<u>Complaint</u>	<u>No. of Times Encountered</u>
Backache	10
Indigestion (heartburn, vomiting, anorexia, cramps, loose stools)	7
Abdominal soreness	3
Sore, stiff neck	3
Pain in extremities	2
Other symptoms (headache; dizziness; urinary freq.)	3

Desse remarks in support of this multitude of complaints:

"Troubles caused by the vibration of poorly suspended engines operating over uneven terrain are well known: digestive upsets, headaches, vertigo and particularly lumbo-sacral pains following shocks transmitted to the vertebral column."

These may be "well known" but do not seem to be well documented in the literature.

Kubik (13) although obviously believing that gastric disturbances do take place, was not able to demonstrate it.

"In an examination of tractor drivers on two state tractor stations in the Bratislava region, particular attention was paid to damage to the gastrointestinal tract. An attempt was made to associate this damage with working conditions, in particular with jolting, but this could not be done with any degree of certainty or reliability. For this, further observations would be necessary, combined . . . with examinations, at half-yearly intervals, of the state of health while doing this form of work. In conclusion, attention is drawn to the necessity for the proper selection of workers, the regular follow-up of their state of health and especially for the elimination of mechanical jolting."

Of course gastric upsets do not always result in intestinal damage. Nevertheless, Kubik (12) in another article says:

"A significant number of the drivers suffer to a varying degree from complaints in the gastrointestinal tract. These difficulties are encountered after several months or several years of working on a tractor. They are expressed most noticeably by a feeling of pressure on the stomach which is most apparent after work, after long shifts and after rapid driving over rough terrain. A loss in appetite, a loss in weight, dyspeptic breakdowns and intensive pain appear one after the other. The pain subsides after resting briefly; however, repeated returns to work lead to relapses of the mentioned problems. More serious findings occur in connection with objective symptoms of disorders in the functioning of the digestive organs, and then with disorders in secretion, tone and motility with over stimulation of the parasympathetic nervous system (hypersecretion, hyperacidity, hyperperistalsis). Tuskievic stated that he observed a spastic condition in the large intestine of the tractor operators who are afflicted. The large intestine is a timely and sensitive indicator of the vegetative breakdown in the organs. As harmful factors, the long range effects on the organism may also lead to morphological changes in the abdomen in the form of stomach catarrhs or ulcerous disorders.

"These pathological changes attest to the breakdown of the nerve mechanisms which regulate the function of the stomach. The reason for the breakdown in the vegetative nervous system involves not only the personality of the patient, but also the environmental factors in working and living conditions; jarring, noise, exhaust fumes, cold, heat, nourishment, etc. But the most important factor in causing stomach disorders from external causes is jarring."

Regarding the possibility of anorectal ailments Clayberg remarks:

"The required prolonged periods of sessile position plus the jarring favors the development of anal conditions. Pruritis, fungous infections, hemorrhoids, and pilonidal cysts must be sought and treated in drivers with complaints in this region."

Clayberg does not indicate if his remarks on pruritis, etc., stem from examinations conducted personally or from the literature, and his bibliography is not such as would rectify this lack.

It was not possible to verify the remarks on pruritis, fungous infections, and hemorrhoids in a literature search using the Index Medicus from 1940 to date or the Current Index of Medical Literature for 1950-1960 with regard to driving or seating. This does not mean that no relations exist between these conditions and seating, but that it is difficult to demonstrate, as is indicated by Warshaw and Turrell's comments regarding pruritis:

"Pruritis ani and perianal dermatitis rarely can be ascribed to a specific cause. Among the factors that may be involved are poor rectal hygiene, excessive perspiration, superficial fungus infections, and excoriation. Occupational exposure to high temperature and high humidity or contact with residues of caustic soaps or solvents used in cleaning work clothes have been accepted as a basis for declaring cases of perianal dermatitis compensable. Instruction in proper anal hygiene, the provision of adequate toilet and washroom facilities, and the installation of ventilating and/or air conditioning apparatus to minimize exposure to excessive heat and humidity will prevent most of the cases of the perianal dermatitis and pruritis."

They do not relate the above etiological conditions to vehicle driving but it is obvious that many of the conditions may obtain for a driver seated for long periods of time in a vehicle, especially under tropical conditions. Clayberg's statement regarding pilonidal sinus disease finds, however, auxiliary evidence in recent literature (Beisenherz, 2; Goodall, 8; Warshaw and Turrell, 20).

The literature on pilonidal sinus disease is extensive.

"During World War II, considerable interest in pilonidal disease was stimulated . . . because of the increased incidence seen." (Blackwell, 3)

Warshaw and Turrell indicate:

"Pilonidal or sacrococcygeal infections are also commonly seen after similar trauma to that region. Pilonidal cysts and sinuses were generally considered to be congenital in origin, but Brearley suggested that they were produced by the intrusion of external hairs into the skin of the intergluteal cleft, just as the lesions found in the finger web spaces of barbers. Regardless of how they are formed, however, they usually remain quiescent until irritated by trauma. Inflammation is generally followed by infection. While rarely serious, pilonidal disease is troublesome

from the compensation standpoint because of the relatively high recurrence rate when treated conservatively and the length of time required to complete healing of the open wound when the more radical method of wide excision is employed . . ."

Goodall (8) in the British Journal of Surg. remarks that " . . . Trauma was shown to be a common antecedent during the war when the familiar term 'jeep-seat' was coined."

His table (reproduced below) is indicative of the amount of time lost from the job, which this disease and its treatment can entail, and gives further support for Warshaw and Turrell's remarks quoted above.

TABLE 2

Relation Between the Method of Treatment Used and the  
Length of Subsequent Disability - in Days - Goodall

	<u>Average Time in Hospital</u>	<u>Average Time Off from Work Following Surgery</u>
Excision and primary closure	18.3	57
Excision and primary closure. Primary healing obtained.	14.4	45.4
Excision and laying open	18	53
Incision and laying open	11.5	37

Beisenherz (2) has the following remarks relating automotive seats to pilonidal sinus disease:

" . . . the developmental theory of Meyer-Burgdorff . . . found support after the Second World War from American authors insofar as these have seen the frequent appearance in the last years of the war of 'raphe fistulas' in young and well nourished members of the military forces. They surmised a relationship with driving on poorly cushioned trucks with cushions made from artificial materials and called this illness 'jeep disease'. Anomalies of the spinal column were never found."

Hardaway (10) states that "Pilonidal disease is apparently much commoner in the military service than in civilian life. This is because (a) pilonidal sinus is a disease primarily of young men, and (b) conditions of military life are conducive to the start of symptoms. A total of 77,637 soldiers were admitted to Army hospitals for pilonidal disease from 1942 to 1945. This is equivalent of five infantry divisions. These figures do not include 9000 other cases of pilonidal cyst admitted primarily for other disease or hundreds of thousands of outpatient visits." One may refer to Goodall's table above to get some idea of lost man time.

Warshaw and Turrell in the following quotation call attention to pilonidal disease's frequent origins in personnel using military vehicles.

"Proctologic diseases of occupational origin have been receiving increasing attention from industrial physicians, proctologists, and those who administer Workmen's Compensation cases. This was stimulated to some extent by experiences in World War II when conditions such as pilonidal abscess, perianal hematoma (thrombosed hemorrhoid), and coccygodynia\* were so frequently encountered in men who were bounced about on the unpadded seats of jeeps, tanks, and other vehicles . . ."

Pruritis, fungus infections, and hemorrhoids have, however, a complex etiology, making it difficult to point up seating as a primary cause. A number of fighter pilots known personally to the author have reported that they feel the incidence of hemorrhoids is higher in their profession than elsewhere. But whether this is a result of confinement to a seat for long periods or of the accompanying forced delay of bowel movements is a matter for conjecture. Mendes et al (14), while agreeing that the incidence is greater in this group than the general population, considers the hemorrhoid condition in pilots as having its origin in the greater "g" forces to which they are subjected.

Warshaw and Turrell point out that "Trauma to the buttocks by repeated bouncing against a hard seat can cause perianal hematoma or infection. This is seen in men who drive vehicles with hard seats over bumpy roads or fields and in those who occupy the saddles on horses, bicycles, motorcycles, and tractors. During World War II these lesions were seen with great frequency by medical officers attached to mechanized units.

"Perianal hematoma, often incorrectly called thrombosed external hemorrhoid, is produced by rupture of a subcutaneous vessel. The tough fibroelastic septa dividing the subcutaneous tissue of the perianal region into a honeycomb prevent the diffusion of the extravasated blood, keeping it sharply localized and often under considerable pressure, causing much pain.

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\* Pain localized in the coccyx or sacrococcygeal joint.

"Perianal infection is seen probably as a sequence of a minute abrasion or fissure of the skin. The congestion of that region due to the trauma is thought to lead to a local reduction of resistance and enhance the spread of infection. The unusual structure of the perianal tissues already described favors the development of relatively deep abscesses with resultant fistula formation. Signs of infection usually are not immediately evident, being first observed from four days to about two weeks after the trauma. The frequency of this sequence of events among horsemen has led to its historical designation as 'knight's disease'."

Clayberg discusses the subject of intervertebral disk syndrome. He states:

"Intervertebral disk syndrome. Jarring of vehicles having few, poor, or no springs for protection of spinal column of riders is an infrequent but important item. The writer has examined officers compelled to ride for prolonged periods of duty in jeeps over rough roads, and such officers have developed severe lower back pains, causing retirement from service with substantiated diagnosis of intervertebral disk hernia or rupture, operative procedure being required in some cases. Enlisted men are as often affected."

Von der Weiden (21), however, indicated that results of X-ray investigation of the entire backbone of 44 professional drivers and a comparable group of 44 factory workers in regard to "spondylous deformans" and intervertebral disc injury did not indicate spinal column deformations. However, she does report that in East Germany chronic intervertebral disc injury in long distance drivers is recognized as an occupational disease. No indication was given that it is recognized as an occupational hazard in any of the other Iron Curtain countries.

Lower back pain has for many years been associated with vague and confused diagnosis, leading in many cases to lumping all such symptoms into the psycho-neurotic category. However, one report (Haluzicky and Kubik, 9) indicates that it can be caused by tractor driving. The English summary of their article was as follows:

"The authors have described pain in various muscle groups starting particularly after long shifts, occurring in summer months, so that work rather than climatic factors enter in. By analysis of the low back pain, vibration myalgia, congenital anomalies, and spondylotic changes were discovered, but particularly important were those concerning the L 4-5 and L 5-S1 discs in 27% of the group. This latter occurred quite frequently in young individuals up to 30 years of age. Degenerative changes were seen, consistent with repeated small traumata which might accelerate the pathological process even in young workers."

Desse (6) remarks similarly:

"The danger of future invalidism is still greater among young subjects with an immature vertebral column and among subjects showing scolioses and the transmittal anomalies L 5-S1, the frequency of which is well known." - - not statistically unfortunately but only intuitively.

"Radiographic examinations of our farmers show signs of vertebral arthritis and lumbo-sacral ligament opacities more frequently than in other professions."

He does not indicate his sources for medical statistics regarding these professions for the areas described.

The following articles from American, Italian, and Czechoslovakian sources are quoted at some length.

The first article by Fishbein & Salter (7) is based on questionnaires to a number of orthopedic surgeons, largely in the middle west.

" . . . A review of medical literature reveals few references to the possible etiologic contributions of truck and tractor driving to various disorders of the spine and supporting structures." (This is still quite true.) "A recent (1949) paper by Clayberg on the pathologic physiology of truck and tractor driving points out a number of conditions related to the jarring to which truck and car drivers are subjected . . .

"From findings available it appears that the question of how much of a medical aspect there is to the occupational conditions inherent in the operation of rough-riding vehicles, except possibly in the field of aeronautics, is one that has not received the attention and study it deserves, especially when the number of such operators is considered . . ."

Their conclusions were that:

"A survey of orthopedic surgeons in the United States definitely establishes that the regular seating on trucks and tractors either causes or aggravates a number of disorders of the spine and supporting structures of drivers . . .

"With more than 10,000,000 trucks and tractors being operated in the United States, exclusive of those in the Armed Forces, the health hazards of driving such vehicles constitute a major medical problem that has not received the attention and study it deserves, either by the medical profession or the manufacturers of such equipment."

That concern with this problem is arising in many places where automotive equipment is being used is evidenced in the following Italian article (Barbaso, 1):

"In a recent work we referred to the incidence of various rheumatic diseases among personnel of a bus and a streetcar transport company. Such personnel consisted of 291 subjects, 213 of whom were employed as operators and ticket collectors and 78 as shop workers. In this brief memorandum I wish to dwell particularly on vertebral column complaints noted among 213 travelling subjects. Their frequency has been compared with that commonly given in statistics on vertebral column complaints among the male population and, in this way, that found among 78 shop workers of the same company, for since they perform the same kind of mechanical work they can serve as a control.

"Among this group of 213 travelling subjects, we found 93 individuals (43.6%) who had arthrosic lesions or scoliosis. In diagnosis of arthrosis we did not consider either painful manifestations of the vertebral column brought out clinically or radiographically, or lumbar or lumbosciatic cases of similar vertebral origin resulting from anamnesis. In fact, these last-mentioned painful manifestations are also normally caused by lesions of the intervertebral disc and fall under the heading vertebral arthrosis (disc arthrosis or somatic disc arthrosis). We also took into consideration vertebral scolioses, since such abnormalities, while resulting from osteo-articular or disc lesions, may cause various kinds of rheumatic type complaints.

"As shown by the before-mentioned data, the incidence of vertebral complaints in the group of individuals which we considered is very high, much greater than that commonly given for the male population in general (about 25%) and also definitely greater than that which we found among the 78 workers who performed the same kind of mechanical shop work (28.1%). Undoubtedly this greater incidence is explained by the type of work performed. In this sense it also explains the frequency of the incidence of vertebral lesions noted with respect to the age and work longevity of the subjects examined.

"It is seen that despite the fact that the frequency of vertebral lesions increases with age and work longevity, vertebral complaints also affect young individuals and individuals who have been performing such work for a relatively short time. In fact, of 75 subjects less than 40 years of age, 28 (37.3%) had vertebral complaints; of 67 individuals with more than 10 years of work longevity, 22 (32.8%) showed signs of vertebral lesions.

"The before-mentioned data are also particularly significant because they are taken from carefully selected personnel, since they are given a careful medical examination when they are hired. Furthermore, it should be considered that from such a group of individuals examined there have automatically been eliminated those subjects who, with the passing of the years, have proved to be prone to serious vertebral complaints such as to cause them to quit work because of the intensity of the pain.

"In analyzing our findings among the 44 subjects affected by spondylarthrosis, we see that 12 of them (27.2%) had suffered in the past from one or more attacks of acute lumbago, 10 (22.7%) had vague lumbago at intervals mainly from fatigue, eight (18.1%) had torticollis or stiff neck at intervals, and finally three (6.8%) had had attacks of cervicobrachialgia. In these 44 individuals, radiological examination of the vertebral column showed arthrosic type lesions of varying importance and in various places, lesions which showed no special characteristics; in fact, it was always a case of typical regressive manifestations shown by the reduction in size and asymmetry of the intervertebral spaces, by the cutting of the edges or sclerosis of the vertebral plates, from more or less pronounced osteophytosis, by the irregularity of the small intrapophyseal articulations, by morphological changes in the vertebral bodies. Such radiological changes in different combinations generally appear to be of small importance; only

in five individuals over 50 years of age had these reached a very serious and advanced state. We noted presence of transitional abnormalities in 12 individuals: seven of these had sacralization of the fifth lumbar vertebra and five had lumbarization of the first sacral vertebra.

"Based on our findings given above and on the basis of data given in literature, which agree in affirming the high percentage of incidence of vertebral lesions in individuals employed in the driving of motor vehicles and in the transport of persons and goods, we believe that it is appropriate to include this profession, which is apparently not a very difficult one, among those in which individuals are exposed to vertebral complaints (miners, railway construction workers, fishermen, porters, masons, etc.)."

Mungo and Guarino (15) summarize their findings as follows:

"On a group of heavy lorry drivers the authors studied the changes in the vertebra caused by posture defects, among which a convex left scoliosis of the dorsal and lumbar tracts was the most important.

"They also found various structural changes in the vertebra themselves consisting in wear of the bodies, spilling, osteophitary arthrosis, rupture (hernia) of the discs, etc.

"The pathogenous mechanics of these changes were essentially established as being in the driving position as well as in disturbances the driver is subject to while driving."

It has been thought that the Iron Curtain countries have no interest in the people who operate vehicles, only in the vehicles themselves. It has often been remarked that the Russians aren't interested in the petty comforts that our people find necessary. The following extensive article does not seem to bear this statement out (Kubik, 12).

"Mechanization is a decisive factor in bringing about the rapid development of agricultural production. Tractors are among the most widespread and useful mechanized means in agricultural production. A resolution of the party and government charges the Hygiene with devoting special attention to the machine operators in agriculture. Although driving a tractor is a relatively new profession, nevertheless, we have already encountered a great variation in health factors and a whole gamut of subjective difficulties which occur in connection with tractor work, particularly with regard to the effects of shaking and bouncing. After protracted periods of work on a tractor, complaints of pains in the abdominal and spinal areas are observed. Almost everyone complains of soreness in various muscle groups. Headaches and considerable fatigue showed up in some cases.

"While riding on a tractor, the worker is exposed to bumps and jolts from the uneven terrain and bumpy roads. In addition, tractors do not have the spring suspension which is found in other vehicles.

"In addition to sharp bumps, the organism of the tractor operator is also exposed to vibrations. The vibrations give rise to impulses of high frequency and low amplitude, whereas the jerks result in impulses of low frequency and high amplitude. The engine causes the vibrations, and rough terrain causes the bumps. While riding, these impulses are disguised, but the resultant jarring has its effect on the driver. The vibrations cause fatigue and headaches which act on the central nervous system. The jerks have the greatest influence on the bone-joint system, which transfers the shocks most easily, especially if the musculature is counteracted as in the case of a tractor operator while driving. In addition to this, the shaking also has an effect on the internal organs which rest on the diaphragm and which are subjected to centrifugal forces arising under the influence of the jolts.

"The drivers frequently complain of pains in the small of the back which has a connection with the work being done. Healthy persons started work and, within several years, began having difficulties. According to Dr. Haluzicky, Bratislava, degenerative changes frequently are met in vertebral regions in young workers up to 30 years old. The encountered changes are explained systematically by repeated microtraumata which can accelerate the pathological process on the vertebra of young people. Chronically repeated microtraumata cause fatigue and relaxation of the back muscles, which eliminates its compensating effect and the shocks are transferred directly to the back. The related breakdowns of the blood vessels along with the unfavorable factors of the external environment accelerate the degenerating changes.

"Many of the subjective complaints of the drivers of pains in the small of the back without any objective findings, are attributed to vibrational myalgias caused by incessant shaking while on the tractor. The drivers also complain of pains in other muscle groups which never reach the same intensity due to a brief interruption in work. For the most part, however, it intensifies all during work; the intensity increasing, the longer the work periods.

"These localized pains are found in the cranio-cervical region and in the regions of both upper extremities and shoulder bindings. The small of the back and the musculature of the lower extremities are also centers of discomfort. Obviously, those muscles which are under the most strain (in the case of a seated tractor driver), are the ones which are affected as described above. If we imagine a tractor going over uneven ground, we see that the center of gravity of the driver's body is constantly changing; therefore, the muscle tone of the various muscle groups must also change in reflection and adapt to the changing position. The return of the body to a balanced position in each instant after a bump contributes to the aching. Most of the complaints are centered in the small of the back, since it bears the brunt of the bumps. At the same time, the musculature there must be in constant readiness to maintain the changing balance. The abdominal musculature is the antagonist. Here, the pains are situated chiefly in the region of the ribs. Pains in the muscles of the upper extremities and in the muscles of both shoulder bindings are typical. The

muscle tension in this muscle zone is caused by long periods of steering and holding onto the steering wheel. The tractor drivers are forced to support themselves on the steering wheel since it aids the latter musculature in maintaining the body equilibrium.

"We find similar conditions in the lower extremities. In some instances, the combination of the poor design of the seat, the great resilience of the springs and the rough terrain pose a real threat of tossing the driver from his seat. In order to prevent this, the drivers brace themselves firmly with their legs against the base and with their hands, they cling to the steering wheel."

## Summary and Conclusions

Little definite information of a statistical nature is available that can be used to conclusively ascribe particular physiological consequences to the combination of seat configuration and vehicle ride characteristics. Although as Busch indicates, it is somewhat purposeless to fashion statistics at the present time although specific syndromes\* are beginning to be reported directly related to vehicle usage.

Clinical opinion seems to be coming to agreement that, as indicated in the body of the report, there is basis to believe that physiological disturbances do arise from riding in and operating vehicles for long periods of time.

If physiological disturbance can be determined to arise from seating consideration in vehicles, it is a matter of concern to the military. Newer weapons tend to demand better performance from the soldier, and it is feasible to assume a degradation in performance if he is afflicted with symptoms such as the authors reviewed here have described.

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\* For a brief note on the problems of muscle strain arising from operating and riding in compact cars, see Strauss (18).

## Recommendations

1. The design for seats to be used in military vehicles should be based on considerations of physiology and anatomy.

2. Seats cannot be considered apart from the suspension characteristics of the vehicle in which the seat is to be used.

3. Since any seat will be used for a period of years by thousands of men, a thorough evaluation is required.

4. This evaluation should utilize the services of competent medical personnel to determine clinical manifestations ensuing from prolonged usage of the seat concerned.

5. A complete definitive technical review of the literature should be made by personnel who are competent to evaluate and comment on clinical symptoms.

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A review of available literature on physiological  
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